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DISCUSSION OF MAXIMUM LOAD CAPACITY OF BAILEY BRIDGES

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DISCUSSION

D. Allan Firmage,[3] Jun. ASCE.—Although at first observation Mr. Stegmaier's paper appears to be only of academic interest to the designer of civilian bridges, it contains certain aspects that may be of considerable interest.

The design and rating of military bridges are somewhat along the line of structural design of aircraft. Because excess dead load cannot be tolerated, military bridges must be designed with small factors of safety and with a high degree of design precision. The nature of the Bailey bridge is such that it is impossible to determine (by purely analytical methods, and within the required degree of accuracy) the buckling limit of the compression chord and the distribution of load among the trusses for the various structural arrangements. Ultimate capacity tests were the author's only method of reaching a sufficiently accurate solution. The use of SR-4 electrical resistance strain gages to measure actual strains in the structure was a great aid in determining stress distributions; and it yielded information as to the maximum local stress that could be expected for any load.

The 10% allowance for impact may appear to be somewhat unsafe when compared with the allowance for impact specified by the American Association of State Highway Officials (AASHO). According to the AASHO impact equation—

$$I = \frac{50}{L + 125} \qquad (1)$$

—the loaded length must be 375 ft before a value as low as 10% could be used. The maximum span permitted for the Bailey bridge was 200 ft; whereas the average span used in military operations is about 75 ft. It has long been the writer's opinion that the AASHO impact limit was very conservative, especially for short span bridges where the upper limit of 30% is used (spans of 42 ft or less). It is on these short span bridges that an excessive allowance for impact results in the most waste of material, because live load is the larger proportion of the total design load. These structures make up the greater percentage of the total bridge mileage in the United States. A less conservative impact allowance would save the taxpayers many dollars for highway bridge construction. This belief in the excessive allowance for impact, as required by AASHO, is partly substantiated by the results of tests conducted in England[4] as reported by G. R. Mitchell in 1949. The results of these tests showed that the impact $\left(\frac{\text{dynamic stress} - \text{static stress}}{\text{static stress}}\right)$ varied from maximum values of +30% to −30%, the most frequently occurring value being 0%. Of a total of 114 occurrences only 20 had impact values greater than 10% and in only 8 occur-

Note.—This paper by Robert B. Stegmaier, Jr., was published in June, 1950. The numbering of footnotes and equations in this Separate is a continuation of the consecutive numbering used in the original paper.

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[4] "Problems of Impact and Fatigue and Their Effect on Permissible Stresses in Cast Iron Girder Bridges," by G. R. Mitchell, *Publications of International Assoc. for Bridge and Structural Eng.*, Vol. 9, 1949, pp. 61–64.

rences were impact values greater than 20%. The bridges tested in England were all short span bridges and the results include

> "* * * a number of tests made with a solid-tired vehicle on one bridge where there was a sunken trench near the mid-span line giving a rise to a one inch (2.5 cm) depression in the road surface."

The paper by Mr. Mitchell, however, fails to state whether the larger values of impact were from this condition of test or not. It is presumed that this rather severe condition would result in larger impact values. The results of the impact tests mentioned in Mr. Stegmaier's paper should be published to stimulate further research in the problem of impact on civilian bridges.

The concentrated load equivalent was used as a convenient method of comparing the capacity of the bridge (concentrated load capacity) against the effect of a vehicle. The longer the span and the shorter the wheel base, the closer will the concentrated load equivalent approach the gross weight of the vehicle. It was a very "handy" tool for comparing effects of vehicles. It was easier to compare concentrated load equivalents than bending moments because the values did not cover such a wide range in going from short span bridges to long span bridges.

Mr. Stegmaier's paper shows the great amount of effort and time-consuming research that was needed in only one small part of the total war effort. It shows, in a degree, that the problem of conducting a war in this present day and age is surely a technical problem. The eventual winner will be the one who can solve the technical problems most expeditiously.

Robert B. Stegmaier, Jr.,[5] Jun. ASCE.—In his discussion Mr. Firmage has touched lightly on the most important problem involved in the design of military bridges. His assertion that "* * * excess dead load cannot be tolerated * * *" might be better expressed by the statement that every pound of material in a military bridge should be used to 100% of its load-carrying capacity. Of the many variables involved in the development of criteria for the design of military bridges, there was considerable background data to serve as a basis for all assumptions except that of impact. Mr. Firmage has indicated that critical examination of AASHO specifications for impact proved them unrealistic for application to military bridges. A primary consideration in the choice of the relatively low value of 10% of the live load was that, on the usual range of bridge spans, heavy concentrated loads in the form of tanks and other track-type vehicles were the governing loads. Such vehicles carry their own roadways in the form of tracks, and these tracks, combined with the cushioning effect of "bogie" wheels, were assumed to minimize impact, as compared to the wheeled vehicles for which AASHO specifications were developed.

It is true that, on longer spans, wheeled tank transporters, which have a relatively long wheel base, were the critical vehicles, but for such spans the live load was a much smaller proportion of the total dead and live load on the structure. In such cases, therefore, the net effect of impact was reduced.

[5] Reports and Statistics Branch, Resources Div., Research and Development Bd., Office of the Secretary of Defense, Washington, D. C.

Recent dynamic tests on a 120-ft span, Bailey-type bridge demonstrated that the maximum impact load on the trusses was 12% of the live load for both a 43-ton tank and a 60-ton, pneumatic-tired tank transporter. These values are comparable to the 10% originally assumed. The maximum impact loads on the floor system of the bridge (stringers and floor beams), using the tank as the test vehicle, were 15% of the live load. The impact load on the trusses was increased to 14% when the tank rode over a 2 in. by 4 in. timber placed on the bridge deck. There is no doubt that the study of impact effects on structures—(1) under peacetime civilian conditions (with well-maintained roads and high speeds) and (2) under military activity in wartime—is a fertile field for valuable contributions to the profession.